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A COMPOSITE MATERIAL FOR VEHICLE HULLS AND  
A HULL MOLDING PROCESS

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

This invention relates generally to the field of molding vehicle hulls.

2. Description of Related Art

10 Various composite materials for vehicle hulls and processes of forming hulls of vehicles are known in the art. Several hulls in the marine industry incorporate molding processes for the surface elements of the shell of the vehicle. Also, several boats incorporate filling of an inner and outer shell with a  
15 core material.

U.S. Patent No. 5,372,763 issued December 13, 1994 to Hordis ("Hordis") describes a method of forming a transom for a boat. Hordis teaches the use of offset keys to space an inner and an outer transom.

20 A method of molding a composite framed resin article is described in U.S. Patent No. 3,711,581 issued January 16, 1973 to Fowler, Jr. et al. ("Fowler"). Fowler teaches a molded article with spaced rods between the layers of the articles to provide support.

25 U.S. Patent No. 5,861,119 issued January 19, 1999 to Merse

("Merser") teaches a method of forming structural panel assemblies. Merser incorporates parallel structural assemblies secured by a foam adhesive.

A boat hull including molding hull structure is taught in  
5 U.S. Patent No. 5,634,425 to MacDougall ("MacDougall").  
MacDougall includes a plurality of longitudinally extending  
stiffening members.

U.S. Patent No. 5,421,283 to Bruggemann describes a type of  
lightweight boat construction that incorporates a PVC pipe  
10 frame.

A method for molding large plastic unitary core boats is  
described in U.S. Patent No. 4,953,494 to McClendon, Jr.  
("McClendon"). In McClendon, the inner core of the boat is  
molded separately from a matching outer section.

15 U.S. Patent no. 4,065,337 to Alter et al. ("Alter") teaches  
a molding process. In Alter, formed sheets that comprise the  
shell of the hull must rest on frames during manufacture.

Reinforced structural panels are taught in U.S. Patent No.  
3,342,665 to Shannon, and U.S. Patent No. 2,72,663 to Durant  
20 describes a method of building veneer boats.

The prior art does not teach or suggest a method of  
structurally bonding two hull sections to one another prior to  
the introduction of foam.

The prior art references do not teach a hull molding

process that teaches the bonding of two hull sections before the introduction of foam. The prior art does not teach the use of an adhesive to form a connector between the two sections of the hull. Also, the prior art references do not teach a method of bonding two shell portions of a hull together while the hull is still in the molds, and then introducing foam while the shell portions are in the mold. Stringers, or braces, are generally required in the forming of a vehicle hull. What is needed in the art is a method of forming a foam-filled hull which does not use stringers.

#### BRIEF SUMMARY OF THE INVENTION

This invention generally relates to a composite material that is to be used for vehicle hulls. There are several methods of forming hulls available. However, the processes generally include the use of stringers, which add to labor costs and uncertainty in the marriage between the two outer layers of the hull. Furthermore, without stringers, in the formation of a foam-center hull the top layer may squeeze against the lower layer, and there would be insufficient volume between the layers for the foam to be introduced between the layers. Alternatively, the expansion of the foam may cause a bond between a top layer and a bottom layer to be pulled apart.

The process of the present invention provides for the molding of a top and a bottom layer. After the top layer and the bottom layer are formed in molds, an adhesive is placed between mating portions of the top and bottom pieces, and the molds are closed together. After the molds are closed, the adhesive operates to form a connector between the top piece and the bottom piece, forming a single piece from the top and bottom layers, with at least one central cavity formed by the closing of the top piece to the bottom piece. While the mold is still closed, foam is introduced into the cavity, forming a core within the cavity. Since the molds are still in place when the foam is introduced, and the adhesive has connected the top piece with the bottom piece. With the connector in place, the expansion of the foam does not force the single piece apart.

In accordance with these and other objects that will become apparent hereinafter, the instant invention will now be described with particular reference to the accompanying drawings.

20 BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

*Sub A<sup>2</sup>* Figure 1 is a block diagram of a method for molding a vehicle hull.

Figure 2 is a block diagram of a second method for molding a vehicle hull.

Figure 3 is a cross sectional diagram of the top piece and the bottom piece of the vehicle hull of the preferred embodiment of the invention before the top mold and the bottom mold are placed together.

5        Figure 4 is a cross section of the finished hull of the invention.

These figures are illustrative only and are not intended to limit the claims to this invention in any way.

#### DETAILED DESCRIPTION OF THE INVENTION

10        As seen in Figure 1, a method is illustrated for the molding of a composite material for vehicle hulls. The molds contemplated are open molds known in the maritime industry, or their equivalent, and comprise a top mold and a bottom mold. In the preferred embodiment, the molds are structurally reinforced.

15        A mold release is first applied to the bottom mold and the top mold 100. The mold release is preferred to be one suitable for multiple releases, such as Prekote®. However, other releases are known in the art and are contemplated in this invention.

20        A gel coat is then applied to a bottom mold and a top mold 110. The bottom gel coat and the top gel coat serve as a protective coating for the single piece released from the mold from ultraviolet light degradation. In the preferred embodiment, the gel coat material is one generally known in the

marine industry, such as Cook Composites and Polymers' (CCP's) vendor number 953WF365 gel coat. However, other gel coats and protective coatings are known in the art and are contemplated by this invention. For example, a premium grade marine gel coat  
5 such as Mese® or MP® may be used in the practice of the invention. A different protective coating may be used on the top mold from the gel coat used on the bottom mold.

A bottom skin coat is applied over the bottom gel coat, and a top skin coat is applied over the top gel coat 120. In the  
10 preferred embodiment, the skin coat material comprises fiber-reinforced plastic, such as a glass fiber in a resin matrix. The glass is preferably electrical glass as is manufactured by PPG, Inc., in the form of chopped roving. The resin is preferably a spray resin such as a monolester DCPD blend  
15 manufactured by Ashland, Inc. However, other resins with comparable properties are known in the art.

Air may be trapped between the top gel coat and the top skin coat and between the bottom gel coat and the bottom skin coat. In the preferred embodiment, the air is removed. Air may  
20 be removed by means such as placing the molds in a vacuum environment, rolling out the top skin coat and the bottom skin coat or other known means. When rolling is performed it is preferred that it be done by hand using resin consolidation tools such as rollers or paint brushes. Where air is still

trapped after rolling, the hardness of the bottom skin coat and the top skin coat is checked, and, when they have hardened, trapped air may be ground out of the layer between the top gel coat and the top skin coat and the bottom gel coat and the bottom skin coat. Preferably, the grinding is accomplished with a pneumatic die grinder. However, the grinding alternatively may be accomplished by hand.

In addition, air may be trapped within the top skin coat or the bottom skin coat. Air is preferably removed as was described above. After the top skin coat and the bottom skin coat harden, the air trapped within the top skin coat and within the bottom skin coat may be ground out with a pneumatic die grinder. However, as also stated above, the grinding may be accomplished by hand.

On top of the skin coat, bulk fiberglass is applied on both the bottom mold and the top mold 130. Preferably, the bulk fiberglass is applied in two layers. The first layer is chopped roving, such as the chopped roving of the skin coat. The second layer is knitted bi-directional reinforced fiberglass. Examples of the reinforced fiberglass for use in the invention are Brunswick Technologies, Inc.'s CM 2415, CM 3215 and XM 1808B, and Hexcel Corporation's Knytex®. However, the bulk fiberglass may also be knitted bi-directional reinforced fiberglass without the roving, or other similar forms of bulk fiberglass known in

the art. The bulk fiberglass is wetted down by a spray resin such as a monolester DCPD blend.

As discussed above, air may be trapped between the top skin layer and the top layer of bulk fiberglass and between the  
5 bottom skin layer and the bottom layer of bulk fiberglass. It is preferred that this air be removed. Methods include those discussed above. Where rolling is done, it is preferred to be done with resin consolidation tools such as rollers or paint brushes.

10 Reinforcements may be applied before or during the process of laying the bulk fiberglass 130. The reinforcements may be wood, such as plywood, phenolic, such as Whale Board® by Ranier RichLite, Inc., or of other suitable materials. Generally, the reinforcements are for attachment points on the finished boats,  
15 such as cleats. Preferably, the reinforcements are incorporated into the bulk fiberglass. For example, in the preferred embodiment, the reinforcements are placed between the chopped roving and the knitted bi-directional reinforced fiberglass. However, the reinforcements may alternatively be added above or  
20 below the entire bulk fiberglass layer.

After the bulk layer has been applied and wetted down, it is given time to cure. After it has cured, a bottom bonding surface and a top bonding surface have been formed in the molds. It is preferred that any bumps and overlaps are ground out with



a pneumatic die grinder at this point of the process. However, the grinding alternatively may be accomplished by hand.

The portion of the bottom bonding surface and the portion of the top bonding surface that are to be in contact with each other comprise a top mating surface and a bottom mating surface. An adhesive is applied to the top mating surface and the bottom mating surface 140. Preferably, the adhesive is applied to one surface and is applied to the other surface when the surfaces are brought into contact with each other. Alternatively, the adhesive may initially be applied to both mating surfaces approximately at the same time. In the preferred embodiment, the adhesive is a methacrylate compound and is applied by a bulk MeterMix® dispensing machine. However, other adhesives are well known in the art. Contact is made between the top mating portion and the bottom mating portion before the adhesive cures.

The adhesive forms a connector between the top mating surface and the bottom mating surface. The connector allows the single piece to be formed to resist the pressure of foam to be introduced. The connector thus takes some of the stress away from the top bonding surface and the bottom bonding surface. For an adhesive such as methacrylate, the preferred distance between the top mating portion and bottom mating portion is 1/8" to 3/4".

The top mold and the bottom mold are then closed 150,

forming a single piece with at least one cavity. For example, in one embodiment of the invention for a 34' boat, approximately eight (8) cavities are formed. Because of the configuration of the top mold and the bottom mold as described above, generally  
5 at least one foam introduction hole and at least one ventilation hole are formed through the single piece into the cavity or cavities in the single piece. In the preferred embodiment for a 34' boat, twenty-eight (28) foam introduction holes are formed. However, where there is a plurality of cavities, one or more  
10 cavities may have one or more foam introduction holes but no ventilation hole. Also, in some configurations, it may be impractical to introduce foam in one or more of the cavities.

In the preferred embodiment, while the bottom mold and the top mold are closed, the ventilation holes and the foam  
15 introduction holes are drilled through the single piece after the single piece is formed 160. Metal bushings in the mold act as guides for forming ventilation holes and foam introduction holes into a cavity in the single piece. In the preferred embodiment, the holes are manually drilled. However, they  
20 alternatively may be drilled with automatic machinery. It is also contemplated that the shapes of the top mold and the bottom mold form the foam introduction holes and the ventilation holes, if required.

Foam is then introduced into the cavity through the foam

introduction hole or holes 170. The preferred method for introduction of foam is with MeterMix® dispensing equipment, such as a foam gun. Generally, the chemicals comprising the foam are premixed in a container, such as a barrel. The foam is  
5 approximately 50% pre-expanded and has a gaseous blowing agent, such as 134A. However, other methods are known in the art. Air in the cavity displaced by the foam is vented through the ventilation hole. When approximately all of the air has been displaced, the injection hole is plugged. Preferably, a toggle  
10 clamp or wood plug is used to plug the hole. Both the foam introduction hole and the ventilation hole may be plugged.

The preferred type of foam for this invention is froth type industrial manufacturing foam. Foams such as those manufactured by BASF, or General Latex, Inc.'s Autofroth® may be used.  
15 However, other foams are also contemplated by this invention. After the foam has cured, the molds are separated and the single piece filled with foam may be removed from the molds.

In an alternative embodiment, additional steps are taken after the curing of the skin coat. Running strakes on the  
20 bottom mold are filled with putty 200 to provide a smooth surface for the laying of the bulk layer of material 120. In the preferred embodiment, the putty is a polyester putty. The putty is smoothed over the strakes; however, other putties and other materials are known in the art providing a smooth layer

for the laying of the bulk fiberglass.

In yet another embodiment of the invention, illustrated in Fig. 2, after the bulk fiberglass layers have been laid and cured 130, clay is placed on the bottom bonding surface 210.

5 The clay is used to determine the distance between the top mating surface and the bottom mating surface. Preferably, the clay is modeling or hobby clay, although other materials are known in the art to be suitable for the purpose, including most types of plastiline clay. In the preferred method, balls of  
10 modeling clay approximately one to one and one-half inches (1-1.5") in diameter are placed approximately every three (3) to eight (8) feet on the bottom mating surface. However, other equivalent configurations are also contemplated.

The bottom mold and the top mold are then test-closed 220.  
15 In the preferred embodiment, the molds are capable of being toggled shut. If the molds are the type that are toggled shut, then it is preferred that all toggles be completely shut. However, the closing of only a fraction of the toggles, such as the front and the back three (3) or four (4) toggles, may also  
20 be performed, as long as the test-closing accomplishes the purpose of determining the distance between the top mating surface and the bottom mating surface. After the molds have been closed, the top mold and the bottom mold are then separated 230. The thickness of the resulting mass of clay is then

measured 240. In the preferred embodiment for an adhesive such as a methacrylate compound, the thickness of the clay, and thus the resulting distance between the mating surfaces, is 1/8 - 3/4" thick.

5 As shown in Fig. 2 at 250 and 260, where the thickness is too small, an area on the top bonding surface or the bottom bonding surface, or both, is ground as necessary to provide the proper cavity width. Where the thickness is too great, an area of the top bonding surface or bottom bonding surface, or both,  
10 is filled. In the preferred embodiment, the areas needing to be filled are filled with knitted bi-directional knitted fiberglass wetted with resin. Adhesive is then applied to the top mating portion and the bottom mating portion 140, and the method continues as shown in Figure 1.

15 A cross section of the hull of one embodiment of the invention before the top mating surface is brought into contact with the bottom mating surface is illustrated in Fig. 3. A cross section of the finished hull is shown in Fig. 4. Figure 3 shows both the top mold 300A and the bottom mold 300B. Layered  
20 on the molds in Fig. 3 are layers of gel coat 302, skin coat 304, and bulk fiberglass 306. As shown in Fig. 3, adhesive 308 is laid on the top of the top bonding surface 310. The adhesive will be applied onto the bottom bonding surface 312 when the top mold 300A and the bottom mold 300B are brought together, as